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NEUTRAL PARTICLE BEAMS IN STRATEGIC DEFENSE

by

Gregory H. Canavan and John C. Browne

ABSTRACT

This report summarizes the main elements of the current Strategic Defense Initiative program, its major risks, and the role neutral particle beams could play in reducing these risks.

I. INTRODUCTION

This report shows that there is significant risk implicit in the sensitivity of the current Strategic Defense Initiative (SDI) program to elements of the threat that are unpredictable or under Soviet control, and concludes that the currently planned means of reducing those sensitivities lack the power to reduce the significnatly. It shows that neutral particle beams (NPBs) appear to be the most likely, and possibly least expensive means of restoring the useful performance margin to the SDI.

Four major components of SDI are at risk: sensors, boost-phase lethality, midcourse discrimination, and survivability. Those elements are described in turn below, after which their combined risk is assessed and alternative program logics that could reduce it are analyzed. The existing program's main problem is that the Soviets have demonstrated the means to negate

the initial interceptors, lasers, and discriminants on which it is based, which would allow them to put the U.S.'s defenses and sensors at risk with modest incremental investment. NPBs could, however, address all three issues with little more cost, risk, or delay, providing the advances in lethality, survivability, and discrimination needed to return useful effectiveness.

II. SENSOR ISSUES

Sensors for missile launch warning are well developed. Current sensors can detect, characterize, and give trajectory estimates for worldwide launches to within a few degrees in a few tens to hundreds of seconds. They are an essential component of any proposed defensive effort, not just SDI. For them to provide advanced warning for defenses against third-country, accidental, unauthorized launches, however, let alone limited, or large attacks, those times and accuracies must improve by about an order of magnitude. Some improvement will come from technology, but most will probably come from larger apertures, focal planes, and computers, which means that the satellites will weigh and cost even more.

The sensors must also survive long enough to perform, but current sensors are at the limits of mass for which developed survivability techniques are effective. Either those means must be improved, or the failure to do so will force an unfortunate tradeoff between performance and survivability. While the most widely discussed threats are direct-ascent nuclear antisatellites (ASATs), the most stressing are heavily decoyed ASATs and space mines--the latter being essentially a very low velocity version of the former.

In the absence of decoys, adequate means exist for self-defense and enforcement of viable keep-out zones. If, however, sensor satellites were unable to tell which of the approaching objects contained a weapon, they could exhaust their defenses to no avail. Interim means might be employed to protect existing assets, but in the mid- to long term, very capable discrimination is required.[1]

Current concepts can only perform surface inspections, from which it is impossible to determine an object's contents, no matter how close it approaches. Interim directed energy weapons (DEWs) can add impulse or thermal tagging, but neither DEWs nor NPBs are fundamental, and both are subject to known countermeasures. NPBs can, however, penetrate even the most massive objects, so they can irradiate satellites, detect the particles and radiation emitted, and infer their contents directly. This fundamental difference between superficial and in-depth inspection is critical to restoring the survivability and effectiveness of space platforms, enforcing existing space agreements, and defining the limits to which future agreements could be verified.

Penetration is also key to addressing the looming problem of co-orbiting objects such as space mines. If the U.S., the Soviet Union, or both have significant numbers of important satellites in space, each would have an incentive to put the other's assets at risk by stationing weapons or decoys nearby, much as they currently put at risk the other's targetable forces on the surface of the earth. Arguments can be made about one's right to enforce keep-out zones, prohibit trailing, etc., but it would clearly be preferable to have in one's own hands a non-lethal means of inspecting threatening objects, inferring the nature of the contents, and taking positive measures before they could draw too close.

Near-term NPBs could directly measure the object's mass, which is the surest discriminant. Mid-term NPBs might be able to measure their fissionable content as well. If the object proved threatening, the NPB would also have the ability to deliver an immobilizing or lethal dose to the weapon or its electronics. NPBs could inspect from a distances of $\approx$1,000 km, which is much greater than even a nuclear space mine's $\approx$100 km kill radius, so one NPB could cover an enclave of $\approx$1,000 possible satellite locations, which is far more than the Soviets could afford to attack blindly. Remote interrogation is possible even with entry-level technology for objects that approach the NPBs

themselves, since in that geometry the NPB's effectiveness grows inversely with the square of the range. Mid-term NPBs could deliver lethal doses at distances of thousands of kilometers in a fraction of a second, so over distances of hundreds of kilometers and tens to hundreds of seconds, near-term NPBs a thousand times smaller could inspect and neutralize threats.

As the NPBs' brightness increases, the range at which they could perform such inspections grows. Mid-term NPBs should be able to perform these defensive functions for other satellites at intercontinental distances, providing the essential defense capability needed by any useful constellation. This satellite-defense role emerges at the earliest levels of deployment and evolves continually with the NPBs' ability to perform their defensive missions. NPBs' should thus produce a capability to meet mid- and long-term space threats that no other DEW could match--and without which critical launch sensors would be increasingly at risk.[2]

III. BOOST PHASE ISSUES

The SDI's current boost-phase strategy is essentially a progression from kinetic energy weapons (KEWs) to (DEWs).[3] The rate of that progression is driven by the rate of deployment of fast boosters, buses, and compact launch areas by the Soviets, which is a variable that the Soviet Union has the expertise and demonstrated ability to control or accelerate.

A. Soviet Control

If these countermeasures were introduced on the nominal decade-long time scale of previous deployments, the progression from KEWs to DEWs would be orderly and should permit DEWs to be developed and introduced on the time scale needed to meet the modestly growing number of compact launchers.[4] If, however, fast, missiles were introduced in compact areas as rapidly as demonstrated Soviet technology would allow, KEWs would have little utility in the boost phase even when they were introduced, and the fledgling DEW efforts would be swamped.[5] Thus, the current, largely KEW, program needs additional lethality, but it

appears that initial lasers could not provide it against aggressive deployment rates.

The fundamental issue is Soviet control of the rate of deployment of compact launchers. That control, plus the KEW-DEW transition's strong sensitivity to it, means that the U.S. program could be dictated by Soviet deployments that could be pushed to levels that would cause the U.S.'s planned progression to fail catastrophically. This sensitivity is compounded by the sensitivity of the initial lasers to known countermeasures[6] such as retrofit hardening,[7] which could render inadequate the limited rate at which larger lasers could be introduced inadequate. The Soviets could accelerate the introduction of compact launchers to the point where the U.S. would have the choice of fielding an adequate number of inadequate lasers, or of deploying an inadequate number of adequate lasers, but not the option of fielding a significant number of lasers that were bright enough to matter. Either choice would make KEW irrelevant and DEW inadequate.

B. NPB-Induced Delays

Mid-term NPBs could disrupt buses and give KEW interceptors an extended intercept opportunity against even compact launches, which is apparently the simplest and most direct way to provide additional boost-phase lethality. Boosters and buses have high leverage because their weapons and decoys would still be on board, which gives a many-for-one payoff.

NPBs do not have to destroy the missiles to have a strong impact. Missiles are critically dependent on the continuous operation of their computers. If enough energy is deposited into their electronics, they will fail, rendering the missile inert during critical periods of deployment and degrading missile and reentry vehicle (RV) accuracies. A single irradiation could degrade the missile; revisiting it could effectively shut it off. The missile might then destroy itself, lose accuracy, or delay deployment; all have about the same effect, given the tight time lines required for the missile to avoid interception. Delaying deployment by a few tens or hundreds of seconds would expand the

KEWs' engagement window enough to give them about another decade of effectiveness.

Brightness and retarget requirements to generate significant delays have been bounded; because each NPB could disrupt a number of missiles in parallel, the constellations required are modest and consistent with current technology goals.[8]

C. Lethal Applications

As performance levels grow, NPBs could also negate missiles and buses, even if they were shielded heavily. NPBs' deposition in depth automatically finds and attacks the lowest damage threshold components. Booster and bus kills are difficult, but NPBs can penetrate down to about 120 km in the atmosphere, which addresses even the fastest missiles that can deploy weapons accurately and decoys deceptively.

IV. MIDCOURSE ISSUES

In midcourse the main issue is obtaining the information needed to negate heavily decoyed threats. Passive and active techniques could be adequate in the near term, but their ability to discriminate growing midterm threats would be limited and indirect because they can only evaluate on the basis of surface appearances. In time the Soviets should be able to make their decoys resemble RVs ever more closely, and their RVs' resemble decoys, as well. If so, it will be increasingly difficult for passive techniques to determine the contents of any but the lightest decoys.

A near-term application of particular significance is the extension of the effectiveness of initial defenses. Adaptive and preferential defenses permit small numbers of weapons to protect a useful fraction of the strategic forces. While such defenses can work with modest discrimination, they do much better with a reasonable level.[9] Initial NPBs could perform that function quite well. The platforms needed for space object inspection and disruption are similar to those required to discriminate near-term threats. Thus, platforms with dual functions could quite effectively provide the discrimination needed for adaptation.

In the near term, NPBs could supplement the information from other sensors; by midterm their capability should be good enough to carry the load; and in the long term, the NPBs' discrimination could shift midcourse to fundamentally favor the defense. From useful standoff distances, NPBs should be effective, survivable, and robust to natural and nuclear backgrounds.[10] They would in time evolve the capability to cost effectively interrogate large threats, negate the RVs found among the decoys, and serve as the rugged, capable sensors needed to direct the overall midcourse engagement.

V. SURVIVABILITY

In addition to the initial lasers' lack of lethality, there is also the issue of the vulnerability of the lasers and sensors, particularly the small, initial ones that would have only a limited, indirect capability to defend themselves or other platforms. Both laser and sensor satellites could be so large that the hardening and maneuvering and deceptive techniques that provide survivability for small KEW platforms would become ineffective.[11] If so, the lasers' contribution to boost-phase lethality, which was already marginal, could be suppressed as well, representing a destabilizing element.[12] Initial lasers could provide survivability only through indirect and untested mechanisms. NPB could provide the discrimination on fundamental mechanisms needed for confidence in survivability.

Midcourse survivability adds the complication of additional unknown objects in orbit, which would become very bothersome in the midterm, if both sides had large presences in space but not adequate means to interrogate them. NPBs' credible information on the nature of intruding objects would then be pivotal in detecting and avoiding threats to the NPBs or other sensors. If NPBs prove to be as survivable as initial analysis suggests, they should be able to assure the survivability of other midcourse platforms.[13]

VI. NPB AVAILABILITY

Large NPBs capable of performing all of these roles, including the lethal ones, would probably be available in numbers only in midterm, but the smaller NPBs required for inspection, disruption, and discrimination could be available in about a decade with dedicated development. Those platforms need not be large or expensive to provide as much lethality as more "mature" lasers. Moreover, they would do so with platforms that were survivable, and, hence, stabilizing in a crisis. The ability to inspect and delay is rooted in technology that is being tested and costed through the ground test accelerator (GTA), which would also provide many of the component technologies needed for initial NPBs.

The Soviets have demonstrated fundamental measures that could negate KEW interceptors, neutralize space chemical lasers, and complicate threats beyond the discrimination capabilities of passive, active, and initial lasers. These factors must be incorporated into any responsible program. NPBs could provide a prompt counter to each of those sensitivities at modest cost and risk on the basis of ongoing experiments and technology programs that lead to roughly the technology levels required to meet those challenges without significant delay relative to lasers, or possibly even KEWs.

VII. PROGRAM LOGIC

Previous sections discussed the threat, responses, and NPB technology; this section analyzes how they fit together. It does so by examining several alternative programs. The discussion pays explicit attention to the separation of the functions of finding, killing, and inspecting (protecting); the layers of boost and midcourse; and the time scales of near, mid-, and long term. The combinations in each time interval can be represented by a matrix whose rows are functions and columns are layers. The narratives summarize the points relevant to each interval that were discussed briefly above and at length in the references cited.

A. Nominal Program

Table I shows the nominal program for a nominal threat.

1. Near-Term Options.

The table indicates that in the near term, finding targets in the boost phase is best done with passive infrared (IR) sensors, and with a mixture of passive and active sensors in the midcourse. Killing targets is arguably best done by the KEW-DEW progression in the boost phase and by exoatmospheric reentry intercept systems (ERISs) in midcourse. This is the part of the program for which there is some agreement.

The need for inspection to survive is clear but often forgotten. Passive measures should suffice for boost-phase KEWs, but NPBs are needed for direct threats to the warning and midcourse sensors themselves. KEWs are useful if they meet cost goals, otherwise it would be better to wait for chemical lasers and deploy them, if they are available soon enough. NPBs might augment KEWs about as well as chemical lasers could. If chemical lasers do not develop favorably, the default position is the aggressive program discussed below.

2. Mid-Term Options.

Finding targets in boost is still best done passively, but, in midcourse, NPBs are required for heavily decoyed threats. Kills in the boost phase can be accomplished with the KEW-NPB delay and the kill combination discussed above. In midcourse, ERISs plus NPBs could provide a simple shoot-look-shoot capability. NPBs are now needed in both layers for inspection.

3. Long-Term Options.

The functions of finding, inspecting, and killing targets remain as described in the midterm; free-electron lasers (FELs) could provide additional brightness for boost-phase lethality against fast missiles, if effective.

B. Aggressive Threat

Table II indicates that if the Soviets deployed countermeasures aggressively, the nominal near- and mid-term programs would collapse for lack of lethality and survivability. Lasers would lack the lethality against an aggressive deployment

to support the KEW-to-DEW progression seen in the nominal program. The best alternative might bypass chemical lasers altogether and deploy NPBs aggressively to preserve the midcourse, which for a decade would be about all the defense there was. NPBs could be used to destroy or delay with KEWs in boost. Later the KEWs could be replaced with FELs, if they developed favorably and could be made survivable. The main loss against an aggressive program is the KEW-to-DEW progression and, hence, the effective defense in boost for about a decade.

C. NPBs Omitted or Delayed

Table III shows the impact of the omission or delay of NPBs, either of which would have about the same effect. While much of the lethality would be lost, the major impact is the loss of survivability. In the near term that might be accommodated by using other DEWs to tag or push objects to give an interim capability. In the midterm the issue would become more serious against aggressive deployments, particulary since the interim DEWs would no longer be able to discriminate or extend KEWs with delays of deployment. In the long term that would mean that the ERISs would be firing blind against threats too heavily decoyed by an order of magnitude for that tactic to be effective. The program shows little improvement in finding or killing targets over time in either layer discussed, and none in survivability. It is not clear that there is any reason for this minimal program to be executed.

D. NPB Applications Summary

Table IV shows the current, energy, power, etc for the platforms needed to perform the applications indicated above. Given the several roles NPBs could play, it is useful to review their requirements and to see that the platfroms required could be available at about the right time. The first function, inspecting threatening objects for survivability involves soft targets, long times, and short distances, which permit low currents, energies, and powers. The resulting platform masses and costs are less than those of earlier shuttle-compatible experiments.

For deployment delay, the current and energy each increase by a factor of ≈3, but the overall brightness requirement is still within the planned block one technology. For discrimination, the power increases several fold, and the divergence must be decreased, but improved technologies should keep the increase in mass per platform down. The number of platforms is in the tens, which would also suffice for killing missile and bus electronics in the near- to mid-term, as well as the RVs found in midcourse into the long term.

E. Summary

A few points stand out. NPBs are almost always the best means of providing survivability. Combinations of KEWs and NPBs appear to be the best in killing in both layers, in part because they reinforce each other, which sustains their effectiveness. Finding targets in boost can probably be done passively; in midcourse it probably requires NPBs. FELs are always last and, hence, of lowest priority.

Finally, against an aggressive deployment, the only viable strategy appears to be to hold midcourse with NPBs, provide whatever delay or kill they can provide in boost as an input to an adaptive midcourse defense, and try to work back into boost with NPBs and KEWs or with FELs over time. If FEL did not develop well, in time this fallback defense would become a midcourse-plus-terminal defense with no significant boost component. By then, however, with excellent NPB discrimination, that approach might work reasonably well.

VIII. SUMMARY AND CONCLUSIONS

That the existing program has significant risk is now obvious to critics and supporters alike. The Soviets have demonstrated the means to negate the initial KEWs, lasers, and discriminants, on which the program is based. They could thus put the U.S.'s defenses and sensors at risk with modest incremental investment. While these challenges are serious, NPBs could use their ability to penetrate to the core of threatening

objects for fundamental measurements and, thus, overcome all three issues.

The SDI is at a crossroads. Heretofore, concepts and technologies were developed on the basis of their maturity and popularity with little regard to their integrated, long-term contributions. SDI now faces the possibility that none of the concepts and technologies under development could withstand known measures that are under Soviet control. The current SDI program might remain viable against a benign, nominal threat, but the planned progression would not work against an aggressive deployment of existing technologies.

SDI needs to break out in several directions: lethality, survivability, and discrimination. Of the known and developed technologies, only NPBs could make the fundamental contributions to all three that are needed to provide a useful level of effectiveness. The risk in their development and deployment is perceived to be significant, but the actual risks and costs are modest, and become smaller with the completion of each experiment and technological development. The means to provide the required survivability for all space constellations are largely in hand. Thus, the greatest risk could be that of prematurely surrendering one of the most promising technologies for moving SDI away from the approaching cul-de-sac.

Table I. The Nominal Program for a Nominal Threat

A. Near-Term Options

	Boost Phase	Midcourse	Notes
find	passive	passive/active	
kill	KEW --> laser	KEW	KE-DE prog
inspect	passive/NPB	NPB	survive

B. Mid-Term Options

find	passive	NPB	decoys
kill	KEW + NPB	KEW + NPB	delay
inspect	NPB	NPB	survive

C. Long-Term Options

find	passive	NPB	decoys
kill	FEL + NPB	KEW + NPB	if FEL
inspect	NPB	NPB	survive

Table II. Aggressive Soviet Deployment of Countermeasures

A. Near-Term Options

	Boost Phase	Midcourse	Notes
find	passive	~~passive~~/active	
kill	KEW --> ~~laser~~	KEW	~~KE-DE-prog~~
inspect	~~passive~~/NPB	NPB	survive

B. Mid-Term Options

find	passive	NPB	decoys
kill	KEW + NPB	KEW + NPB	delay <u>only</u>
inspect	NPB	NPB	survive

C. Long-Term Options

find	passive	NPB	decoys
kill	FEL + NPB	KEW + NPB	delay
inspect	NPB	NPB	survive

Table III. NPB Omitted or Delayed

A. Near-Term Options

	Boost Phase	Midcourse	Notes
find	passive	passive/active	
kill	KEW --> laser	KEW	KE-DE prog
inspect	passive/NPB	NPB	survive

B. Mid-Term Options

find	passive	NPB	decoys
kill	KEW + NPB	KEW + NPB	delay
inspect	NPB	NPB	survive

C. Long-Term Options

find	passive	NPB	decoys
kill	FEL + NPB	KEW + NPB	decoys
inspect	NPB	NPB	survive

Table IV. NPB Application Summary

Application Type	1 Inspect	2 Delay	3 Discrim	4 Mis & Bus	5 RV Kill
Current (mA)	0.1-1	30	100	100	300
Energy (MeV)	25-50	100	200	200	250
Power (kW)	5-25	3,000	20,000	20,000	75,000
Divergence (μr)	10-20	10	3	2	1
Brightness	10^{14}	10^{18}	$2\cdot10^{18}$	$5\cdot10^{18}$	$8\cdot10^{19}$
Dwell (s)	10-100	0.01	0.03	0.1	1
Retarget (s)	10-100	0.01	0.03	0.1	1
Range (km)	300	1,000	1,000	1,000	1,500
Mass (ton)	20	30	40	50	60
Cost ($M)	100	200	250	300	400
Number	1-10	20	30	40	50
Detector (ton)	3	-	4		
Cost ($M)	10		15		
Number	1-2/		2-4/		

REFERENCES

1. G. Canavan, "Defensive Platform Size and Survivability," Los Alamos National Laboratory report LA-11244-MS (April 1988).

2. G. Canavan and J. Browne, "Roles for Neutral Particle Beams in Strategic Defense," Los Alamos National Laboratory report LA-11226-MS (March 1988).

3. G. Canavan and J. Browne, "Where Directed Energy Stands in Strategic Defense," Los Alamos National Laboratory report LA-11172-MS (January 1988).

4. G. Canavan, "Directed Energy Architectures," in Proceedings "SDI: the First Five Years," Los Alamos National Laboratory report LA-11285-MS (March 1988).

5. C. Cunningham, Energy and Technology Review, November 1987, p.14.

6. N. Bloembergen and C. Patel, "Report to the American Physical Society of the Study Group on Science and Technology of Directed Energy Weapons," American Physical Society, New York (April 1987); published in Reviews of Modern Physics 59(3), part II (July 1987).

7. G. Canavan, "Laser Countermeasure Impacts and Penalties," Los Alamos National Laboratory report LA-11264-MS (April 1988).

8. G. Canavan, "Impact of Defense-Induced Delays on Boost Phase Performance," Los Alamos National Laboratory document LA-UR-87-3499 (October 1987).

9. G. Canavan, "Parametrics of Adaptive Preferential Defense," Los Alamos National Laboratory document LA-UR-87-3224 (September 1987).

10. G. Canavan, "Nuclear Effects on Strategic Defense Sensors," Los Alamos National Laboratory document LA-UR-87-2986 (September 1987).

11. G. Canavan, "Defensive Platform Size and Survivability," Los Alamos National Laboratory report LA-11244-MS (April 1988).

12. G. Canavan, "Crisis Stability in Context," in Proceedings of the Conference "Crisis Stability-the Offense/Defense Relationship," Los Alamos National Laboratory document LA-UR-86-3664 (October 1986).

13. G. Canavan, "Survivability of Strategic Defensive Concepts," Los Alamos National Laboratory document LA-UR-85-1583 (April 1985).